[*Reprinted from "Congress of Arts and Science, Universal Exposition, St. Louis, 1904," Vol. VI.*]

THE PRESENT PROBLEMS OF TECHNOLOGY

BY LEWIS MUHLENBERG HAUPT

[**Lewis Muhlenberg Haupt,** Consulting, Civil, and Maritime Engineer, Philadelphia, Pennsylvania. b. Gettysburg, Pennsylvania, March 21, 1844. Graduate, United States Military Academy. Resigned 1869. M.S. University of Pennsylvania; Engineer Fairmount Park, Philadelphia, 1869–72; Assistant Examiner United States Patent Office, April to September, 1872; Professor of Civil Engineering, University of Pennsylvania, 1872–92; Assistant, United States Light House Service, 1874; in charge of Geodesy of Pennsylvania, 1875; Secretary of Bureau of Awards, Philadelphia Centennial Exposition, 1876; member of Nicaragua and Isthmian Canal Commissions, 1897–1901. Has received many medals and awards for discoveries in physical hydrography and harbor improvements. Member of Franklin Institute; Pennsylvania Historical Society; Institute of Mining Engineers; Engineers' Club of Philadelphia; American Philosophical Society; American Association for Advancement of Science; American Society of Civil Engineers; Geographical Society of Philadelphia; National Geographic Society. **Author of** *Working Drawings; Engineering Specifications and Contracts; The Topographer; The American Engineering Register; A Move for Better Roads;* and numerous reports and special pamphlets on transportation and engineering topics.]

STANDING in the shadow of the century which this greatest of expositions signalizes, it is fitting that one should consider its fruition, as typified in these exhibits, and also indulge in a forecast of the magnificent possibilities which they portend.

Amongst the varied subjects assigned for the consideration of this distinguished international Congress, that of "Present Problems" would seem, from its title, to be restricted to the existing status of civil engineering; yet it is so intimately related to both history and prophecy as to involve a brief reference to its past evolution and its future potentialities.

This is the more evident when it is considered that the present is but an infinitesimal link between the two infinities, past and future; the former, being the storehouse of models, tools, and experiences; the latter, the great laboratory of psychological possibilities, rendered attainable only through the application of present activities.

Whenever the curve of progress[1] in any art or science may be traced from sufficiently exact data, its present status becomes at once known and its prospective possibilities may be predicted within reasonable limits of certainty, under similar conditions.

It is by such graphical records of quantitative events that the composite results of history are most clearly projected forward into the domain of accurate predictions. The grandest problem of the present is to portray definitely that curve of progress which will point the way most surely for succeeding generations.

[1] See *Scientific Research*, by Dr. R. H. Thurston, *Science*, vol. XVI, 1902.

To this end it is important that all of the elements which determine its *locus* should be duly weighed and coördinated, since the resultant law and prediction must depend upon the accuracy of, and the interpretation placed upon, the available data used in the compilation.

Some of the physical elements are reasonably well understood with reference to the laws governing their action, such as universal and terrestrial gravitation; the relations of thermic and dynamic, chemical and electric energies; the conservation of force, or the mutations of matter and the like; but who can fathom the basic principles underlying all physical activities and trace the origin of all energies as revealed in the life of organic bodies?

In the language of our lamented and distinguished physicist, Dr. R. H. Thurston:

"All life and movement, whether of man, animal, vegetable, seasons, suns and planets, arts, commerce, civilization, intellectual, moral or physical worlds, depend upon transformations of preëxisting energy. . . . We have learned to compute the velocity, refraction and reflection of light, but we still know little of its exact character as motion of molecules.

"We know the related form, heat-energy, in its sensible effects; but we are still unable to differentiate the one from the other. . . . We can produce and utilize electricity in many ways, but we do not even know what it is or how its transformations from other energies are effected. We work with these three forms of power, but we do not know what is the nature of the substance through which they act to produce their beautiful, marvelous, world-impelling effects." He adds in substance:

The chemist, by analysis, can determine the composition of compounds, but he has only recently discovered that his theoretical basic atom can be atomized. The physicist finds in the spectroscopic lines a strange language of which he lacks the key. He can isolate the phosphorus of steel, but cannot produce that of the glow-worm or the firefly. The analyst can separate organic matter into its elements, but he cannot by synthesis reconstruct the storage batteries of brain and spine nor the subtle alchemy of the bee, which converts the nectar of the rose into its sublimated honey, nor the vegetable verdure of the field into the life-giving, lacteal pabulum of the mammal for the sustenance of its offspring.

The astronomer has unraveled the laws of the motions of the celestial bodies, but he is unable to determine their duration, origin, or destiny. His little span of life is all too brief to enable him to reveal the secrets of their Maker.

The geologist probes the bowels of the earth, from its loftiest to its lowliest depths, but fails to ascertain its age or longevity or to

state whether it shall endure for a million years or perish in a season.

The biologist has yet to learn the mysteries of life in plant and animal and has not even unraveled the secret of sex in generation. He studies the mechanism of the fish, but cannot explain the process of separating the oxygen from the medium in which it moves; so likewise he may understand the structure and mechanism of the bird, but fails to learn the mysterious power whereby it soars aloft, and, perceiving its prey from afar, captures it.

The anatomist may know to an ounce the power developed in an animal per pound of muscle, but he cannot say how that power is originated, transferred, or exerted by the transmitting thread of the working muscles. Our authority concludes:

"The engineer has learned how to convert the potential energy of perhaps a myriad ages into steam and to apply it to the dynamics of the factory or locomotive, but in doing so he wastes from four fifths to nine tenths of it. He transforms the elastic force into an electric current, but frequently loses as much as he applies at the tool's edge. He diverts the energy of the waterfall into an electric-light current with its concomitant heat-rays, while the glow-worm shames the man, producing light without heat and heat without light.

"He crowds his fellow man into mills and factories, but he has not yet solved the social problem of giving to each an individual life, work, and wage, with comfort, health, and happiness in just proportion."

Thus the man of science finds that the acquisition of learning, gain in knowledge, and increasing appreciation of the wonders of creation, only serve to impress upon him the greatest responsibilities, possibilities and opportunities as well as the mightier mysteries of its Maker, stimulating him to nobler aspirations, more earnest labor and higher aims and giving him a larger faith and a stronger sense of the infinitude of duty and opportunity.

In short, no more sublime arraignment of the impotency of man to solve the ever present problems of his existence and necessities, in the most economic manner, can be found than that recorded in the closing chapters of the Book of Job, wherein the Lord charges him with "darkening counsel by words without knowledge" and proceeds to catechize him as to the origin of the world and its phenomena, in a manner so profoundly majestic that most of the queries remain unanswered even unto this day.

These same interrogatories therefore constitute a catalogue of present problems in all departments of science, and their solution can best be approached only by a closer communion with the omniscient Source of all Wisdom.

Most of the great inventions and discoveries which have ennobled and advanced civilization have come from inspiration and deep research, prompted by the exigencies of time and place, yet but few efforts have been wholly successful, for, as the poets have said:

> "God hath appointed wisdom the reward of study!
> 'T is a well of living waters,
> Whose inexhaustible bounties all might drink,
> But few dig deep enough."

Yet let no one fear that the field of research in any of the mental or physical sciences will ever become exhausted, for the Source is infinite.

If all the wisdom of all the sages of mankind, in all ages from the foundation of the world, were summed into a series and integrated between the limits of zero and infinity, they could not compass the unfathomable resources of the Almighty. "Can man by searching find out God?"

To solve the problems confronting the present generation, it is fundamental that the laws and properties governing mind and matter be more fully understood and better applied.

Much energy is wasted and many failures follow from the crude and inexperienced methods adopted, which too often violate the laws of nature and leave but a wreck to tell the story; for "few dig deep enough."

Some of these laws are so occult that man has not yet wholly unraveled their mysteries. Has not the wisest of kings admitted: "There be three things which are too wonderful for me, yea, four which I know not: The way of an eagle in the air; the way of a serpent upon a rock; the way of a ship in the midst of the sea; and the way of a man with a maid."

And do not these four things involve all the elements of the technological problem embodied in the transportation question of today? aëronautics, dynamics, navigation, and psychology, — transportation in the three media of air, water, and land, as well as such mental conceptions of their conditions and requirements as shall render them all equally available; which state man has not yet attained unto. There is therefore a large sphere still open in this field for future research.

It will be the main purpose of the writer, therefore, to outline the elements which must be focused upon this particular phase of economic transportation, having in view the attainment of the best results.

This attainment is conditioned upon something more than the fundamental conception of the ideal or its mere graphical expression in the formal technology of the shop or the patent office. Its

practical fulfillment necessitates a large accumulation of means, men, and materials, and their intelligent coördination in certain prearranged sequences, at definite times and under favorable environments. Moreover, it is essential that all of these factors should work together harmoniously under a single controlling head, impelled by an earnest, zealous, generous, and humane desire to secure the best effects. But it, unfortunately, too frequently happens that vested interests, jealousy, ignorance, cupidity, conservatism, strikes, and physical obstacles conspire to delay or defeat the best-laid plans.

It becomes the part of wisdom, therefore, to consider both sides of the equation before embarking on any extensive innovation, in the nature of works affecting large interests, however beneficially.

The successive stages which mark the progress of great enterprises may be conveniently formulated into a *General Law of their Development,* of which the first step is *educational.*

It is opposed by

(1) *Ignorance,* on the part of the public as to its possibilities;

(2) *Indifference,* as to its economics, after they have been stated;

(3) *Incredulity* as to its feasibility, or utility before demonstration.

The second step enters the forensic arena where efforts to secure authority from legislative bodies are met by

(4) *Argument* which, failing to convince, leads to

(5) *Bribery,* instigated by vested rights or cupidity, and

(6) *Patronage,* withdrawn as a punishment to the offenders, or granted as a reward for opposition. But should the project outlive these allied enemies and enter the third phase of active construction, the opponents then have recourse to

(7) *Violence,* by use of physical obstacles or force to obstruct the works;

(8) *Persecution,* leading to an impugnment of the motives, character, and credit of the parties at interest;

(9) *Murder,* either by premature death from excessive futile, unrequited efforts or by actual assassination or war, to remove the guiding spirits of great movements and thus debar their consummation.

These psychological phases being outlived and the physical forces being overcome, the way to success is at length assured. The former elements are not so often taken into the account as the latter, yet they are frequently the most subtle, uncompromising, and intangible. Underneath many of the great achievements of the world, in the arts of peace, there lies buried a romance of heroic endurance, self-abnegation, and masterful resource, intensely realistic, which would put the pages of fiction to shame, were they made public. Truly, "Peace hath her victories no less renowned than war."

Whilst the above reflections may appear to be merely "glittering generalities" they are in fact fundamental requirements in the successful execution of great projects, since, however thoroughly an inventor may have convinced himself of the great practical economy of his theory, he cannot point to his demonstration as a basis for public confidence and the underwriting of his conceptions, until he has established his precedent; and, on the other hand, it is impracticable to establish his claims by actual works, until he has secured his capital and authority. Especially is this true of great improvements involving governmental jurisdiction, where the personnel and responsibility for appropriations are constantly shifting, and trained experts are not permanently available in the conduct of the works. Although this is a problem of government, it is intimately related to the questions at issue, viz., the work of the civil engineer in providing the way for the safe, rapid, and economical distribution of the products of the earth for the benefit of mankind. Works of this class, requiring the opening of lines of least resistance between distant centres, are impracticable without the exercise of the rights of eminent domain, accompanied by the accumulation of large amounts of capital and the control of labor whereby the physical resistances to traffic may be reduced to a minimum.

Of the three elements, earth, water, and air, the first offers the greatest resistance because of its density and the irregularity of its surface. It has therefore been the crucial problem of all ages so to modify it that "every valley shall be exalted and every mountain and hill shall be made low, and the crooked shall be made straight and the rough places plain," that a highway might be there, over which the peaceful revolutions of the wheels of commerce might cement the nations of the earth and distribute its products. But whilst history testifies to the excellence in alignment, grades, and durability of some of the ancient roads, it fails to record any evidences of such magnificent avenues of trade as have been developed within the space of a single life in the railways constructed during the past century.

These were unknown and impossible prior to 1825, since the state of the mechanic arts did not furnish materials in sufficient quantity and quality to permit of such constructions. The demand, however, created the supply, the storehouses of the earth yielded an abundance of the raw materials, the railways and waterways assembled them at convenient centres of industry, the metallurgist and chemist refined and reduced them to improve their quality and durability; the mechanical and electrical engineers developed new machinery for increasing the output at reduced cost, and thus supplied the markets with structural materials for roads, bridges, and buildings far beyond any possible conception of even fifty

years ago. Then, steel rails were unknown and the durability of the wrought-iron rails, which had supplanted those of cast-iron, was limited in some instances to a few months only, but at this critical period the invention of the Bessemer pneumatic process, followed by Gilchrist, Siemens-Marten, and others, supplied an urgent necessity as to quality; the various inventions of George and John Fritz, Alexander Holley, William R. Jones, Nasmyth, Nobel, Krupp, and many others met the demands for quantity, while the development of commercial channels and establishment of improved plants at strategic points has reduced the cost and increased the output to such an extent that there is no retardation as yet visible in the curve of progress so far as the quantity is concerned. The last fiscal year (1902) shows an increment of 9626 miles of railroad in the country which exceeds that of any year since 1890, so that the demand for construction material continues to be one of the problems of the present.

Especially is this the case with wooden cross-ties having a life of only from seven to ten years. They require frequent renewals at the expense of our hard-wood forests, with incidental injury to the entire country from denudation, causing rapid erosion of uplands, floods, and barren wastes. Therefore the recently established policy of irrigation and reforestation has come none too soon to check the evils of the wholesale slaughter of our forests.

The increasing paucity of timber and the greater strength, durability, and economy of the metals have led to their rapid substitution for the vegetable fibers, in most of the engineering structures, but the tendency is now returning strongly to the use of stone, brick, or concrete wherever they are practicable and available, as the best material for bridges and buildings. Where they cannot be secured, artificial concretes and cements are frequently used either singly or in combination with the metals in the form of meshings for imparting tenacity. Although much progress has been made in this class of material, it yet remains to discover the secret of the ancient compounds as instanced in the remarkably durable water-tanks of the Arabs, built at Aden about 600 years B. C., and still in a perfect state of preservation.

Notwithstanding the extended researches made upon the properties of material for structural purposes, much still remains to be discovered. One of the latest investigations made as to the use of pure sand, encased in light sheet-metal tubing, merely to prevent it from flowing, reveals some astonishing results in transmitting pressure in the form of beams subjected to cross-strains, or in the form of columns carrying heavy loads. These investigations, conducted by Prof. A. V. Sims, may result in important economic changes in engineering structures in the near future, when reduced to a practical basis. They cannot be elaborated in this paper.

But the selection and preparation of suitable materials for structures are details which rather belong to the domain of the chemist and physicist than to the engineer whose province it is to design, assemble, and direct work, whereby he may more generally apply the resources of nature to the wants of man.

Fuel

For this purpose, power is a fundamental factor, and for many years it was readily derived from the forests, so generously dispersed over the earth; but the rapid increase in the demand for all classes of motors as well as for domestic and structural purposes has threatened an early exhaustion of this supply. For locomotives, it soon became impracticable, while for the modern steamship it would be absolutely impossible. With the discovery of coal and its stored energy, the world was revolutionized. The first quarry for anthracite was opened at Summit Hill, Pennsylvania, in 1792, but the cost of hauling to the market was such as to prohibit its use. Thus was stimulated the construction of the Lehigh, Schuylkill, and Union canals and the Switchback Railroad early in the last century, the progenitors of our extensive system of public works, which has been developed by private capital and enterprise with occasional aid from local and general governments until the railroads of the country now exceed 215,000 miles, representing a capital of over 14,000,000,000 dollars and carrying over 1,200,000,000 tons of freight per annum, at an average cost of 7.6 mills per ton-mile.

The rapid increase in the demand for anthracite coal from the Schuylkill and Lehigh regions resulted in a maximum yield, for some years, of 65,000,000 tons per annum; but the discovery and working of large deposits of soft coal in West Virginia and many other localities, as well as the greater cost of mining, has reduced the output of hard coal to about 59,000,000 tons, with resulting increase of price, while the bituminous mines are now furnishing 260,000,000 tons. This, with the opening of the free-working iron ores of Lake Superior and the exceptionally cheap transportation on the Great Lakes, has concentrated the mammoth iron and steel plants near their borders and given to the world a new stimulus in structural materials. Coke, natural gas, and petroleum have also aided in the general movement for cheaper power, and the generation of artificial gas, as the most effective form of energy, has proceeded, *pari passu*, with the demand for greater economies. Attention is now being concentrated upon the utilization of the dynamic agencies of the earth, found in her water-courses, atmosphere, and electricity, to great advantage for the generation and

transmission of power through long distances and under high tension, with corresponding gain in efficiency. Yet these fields are still in an embryotic state. The possibilities of the radio-active group is at present beyond the power of man to predict. The accomplishment of alleged impossibilities is becoming a commonplace event.

The great economy and convenience of fuel in a gaseous form would seem to be manifest from the mere statement of the relative calorific powers of wood, 6480° F.; coke, 13,550° F.; bituminous coal, 13,692°; anthracite, 14,200°; ordinary illuminating gas, 23,000°, and natural gas 35,000°, which makes it nearly six times greater than that of wood and threefold that of coal, yet a modern publication recently announced the superior "economy of coal as compared with oil and natural gas for fuel."

In 1881 the late Sir Frederick Bramwell predicted that by the year 1931 the steam engine would be of interest only as a relic and would be supplanted by gas motors. Subsequent facts sustain in some measure the prediction, for to-day they have reached units of 1750 h. p. and are extensively used in many industries.

The fear that the introduction of electric plants would exterminate gas for lighting and power has not been realized, since it is found more economical in many cases to make the gas-plant supplementary to the electric and thus increase the scope and efficiency of both. But the application of electricity as a motor, whether developed from water or steam, is merely a phase in the evolution of power, which will ultimately yield in large part to the superior advantages of pneumatic transmission from the natural sources now available in the great waterfalls of the world, when they are more fully appreciated and properly harnessed.

Although much attention has been devoted to the application of the tidal energy to manufacturing purposes, but little practical use has thus far been made of it. This enormous storehouse is yet awaiting the touch of a master hand to utilize it advantageously.

Aside from the source and character of the power which may ultimately be employed, there is also great room for further economies in the handling of the enormous tonnage already required to meet present demands. Here the problem has been and still is to increase the ratio of live to dead load and to reduce the resistances by betterments in alignment, grade, distance, and terminal facilities even at large increase of capital. Still the delays in handling and drilling trains, composed of relatively small units and containing miscellaneous freights, in complicated yards, and the use of cars for many days for storage, necessitates great expense for which no adequate solution has been provided, although some relief may be obtained by the earliest possible transfer to waterways at

the nearest practicable point, thus substituting the short for the long haul, in some cases. In others, where bulky freight, like ore, coal, or grain is handled, great improvements have been introduced so that the entire contents of each car may be dumped through chutes into the hold of the vessel in one operation. The capacity of the car has also been increased so that instead of the paying load being less than the weight of its carrier, it is now about three times greater. Probably the greatest advance in economic transportation ever effected was that which has revolutionized the movement of petroleum from the oil-wells of Pennsylvania to tidewater. This product was formerly handled by the trunk-line railroads in specially constructed tank-cars, required to return empty, thus reducing the live load to about 25 per cent of the total for the round trip and costing forty cents per barrel for the freight. To control the market and limit the output a combination was effected amongst the common carriers, which made it impossible for independent producers to market their oil.

In this extremity, *carte blanche* was given to an experienced engineer,[1] in 1878, to secure a continuous right-of-way, in fee, across the states of Pennsylvania and Maryland and to construct a pipe-line to the seaboard, without the exercise of the right of eminent domain and in the face of a most determined and well-organized opposition. By tact, energy, and strategy, this was successfully accomplished in a remarkably short time, and by the use of the principle of the hydraulic gradient and the mutually automatic regulation of the pumping-plants, of which only four were required, the cost of this movement was reduced ninety per cent and the cordon was broken, to the great relief of both producer and consumer. After which demonstration, general pipe-line laws were adopted and other lines constructed so that the tank-car is now almost a relic of the past. Thus the oppression of a trust has operated to effect an economy which has reacted upon it for its own greater emoluments as well as for the public benefit.

The engorgement which has resulted in railroad centres from the concentration of freight at certain seasons may be partially relieved by so improving the feeders and outlets of all the avenues of transportation as to distribute the movement more uniformly over a longer period by the improvement of the *common roads* to make them available at all seasons, with the expenditure of less power and also of the internal *waterways* of the country, that they may be utilized to relieve the traffic by distributing raw materials which will not bear a long rail-haul. Moreover, the bars which obstruct all harbor inlets along alluvial coasts constitute a serious obstacle to the general distribution of commerce by requiring ves-

[1] General Herman Haupt.

sels to clear light, wait for favorable conditions of wind and tide, or store their freight for lack of sufficient draught. It is even now true that the most economical vessel cannot be built because of the existing limitations of channels and ports, not yet removed, and which, notwithstanding the great improvements in hydraulic dredging-plants, cannot be permanently relieved by these mechanical devices.

The great fertile plains and deltas at the mouths of sedimentary rivers are but the natural depositories for the detritus fed to them by their hydraulic conveyors whose source is in the highlands, which streams carry hundreds of millions of yards of earthy matter to the sea, where it must ultimately rest.

The problem here is, then, so to dispose of this deposit by natural agencies as to prevent its obstructing the channels of commerce. This can be accomplished by utilizing the potential energy of the stream itself by means of a concave resisting medium, placed across the bar in such position as to develop a reaction and scour, which changes the form of the channel and transports the sediment laterally to the counterscarp thus created, and from which the waves and littoral currents remove it.

This method has been demonstrated by actual experience and is found to effect great economies in cost of construction and maintenance, since the trace of the work is less than half as long as that required by the preëxisting methods, and there is no corresponding bar advance, but an automatic adjustment of the channel and dump to the requirements of that particular stream and locality.

This is a physical problem which has impressed itself with more and more emphasis, because of the rapid strides made in commerce and manufactures and the greatly increased demands for larger tonnage and correspondingly deeper channels. The mere cutting of a ditch across an ocean bar in the face of the ever active forces which created it is not a satisfactory nor an economic solution of this question. It is estimated that the automatic reaction breakwater would have saved over fifty millions of dollars in the past decade in this country alone, had it not been for the conservatism which was unable to concede its advantages prior to an actual demonstration, and which has debarred its general introduction.

This incident is cited, without detail of the resistances it has overcome, merely to illustrate the truths of the general principles enumerated, as to the elements opposed to progress, in the introduction to this paper.

Returning now to the general theme as to the future of economic transportation, it will be found necessary to devote large appropriations from the treasuries of states and nations to the betterment of the public highways, for the general welfare and as feeders

to the extensive systems of railroads, that they may utilize their rolling-stock and power to best advantage. In this work the railway companies can well afford to expend large sums for road-metaling in coöperation with local interests, as some are now doing, instead of building railroads for their exclusive use and control, to be maintained at great cost. The highway, thus improved, will become available for all classes of vehicles (and at all seasons), from the freight-wagon to the automobile, and will play a most important part in the commercial, social, and industrial well-being of the country. The introduction of the trolley has also served to elevate the general condition of mankind by the facilities it has afforded for the circulation of mind and matter at a very reasonable cost; while the various devices for transmitting knowledge by electric agencies, with or without metallic conduits, has given a great impetus to the interchange of knowledge and the promotion of all classes of improvements. Yet each innovation has had to establish its *raison d'être* by a long contest and only the fittest have survived. The war of extermination waged by certain transportation monopolies against competition has in general established the principle that the greater the distribution and mobilization of the population, the greater the resulting benefits to the common carrier.

Thus the improvement of waterways has invariably increased the profits of the railways from the resulting greater tonnage even though carried at reduced rates; the building of trolleys, so long bitterly opposed, is now recognized as a public benefaction; the improvement of the highways, so strenuously resisted by the rural districts, is now hailed with delight as adding immensely to the value of the farm and at the same time reducing the cost of its products to the consumer.

This apparent paradox results from the saving in the waste formerly incurred in overcoming needless resistances, which has gone to increase the margin available for transportation for the benefit of producer, consumer, and carrier alike.

The Isthmian Canal question, the solution of which has been the desire of nations for four centuries, is still an ever-present problem. Though a route has been selected and the right-of-way secured, the canal is not *un fait accompli.* Were it so, the cost of transportation, by water, between the North Atlantic and North Pacific ports would be reduced to about one third of the existing rates, with far greater safety and with a corresponding increase in the potentiality of the fleets. Even under existing conditions, with the necessity of circumnavigating South America, the railroads cannot compete with the Cape Horn route for the reason that the average

charge for the overland movement, at 7.6 mills per ton-mile, would make the cost of transportation about $21, which is more than the market value of the great bulk of the tonnage.

It is therefore a physical impossibility, at present rates, to carry this traffic by rail at a reasonable profit, whereas it could readily be moved by the water-route at a charge of less than $5 per ton, thus stimulating manufactures and building up a higher class of freight for local distribution with a shorter haul, for the general benefit not only of the railways but of all parties at interest. Under existing conditions the total overland tonnage of all the transcontinental lines probably does not exceed 2,000,000 tons per annum.

It is estimated that an Isthmian route would save to the commerce of the world not less than $200,000,000 annually, or an amount equal to our foreign freight bill, so that there can be no question as to its justification and imperative necessity at any cost.

Another pressing desideratum in the development of international commerce is the enlargement of the internal waterways of our own country, which have not kept pace with the traffic requirements.

The state of New York has at length awakened to the necessity of meeting the competition of her energetic neighbors and is about to respond generously to the demand for a larger waterway from the Great Lakes to tidewater, hoping by a limited twelve-foot draft to compete successfully with one of much greater capacity traversing a shorter route. The fallacy of this proposition would seem to be self-evident, but the general government makes no appropriation for this great enterprise.

The Chicago Sanitary District has by its own contributions accomplished the triple benefits of improving its water-supply, disposing of its sewage in a harmless manner, and creating an ample navigable channel across the "Sag" between Lake Michigan and the Illinois River (a model of which may be seen in the Liberal Arts Building).

It now remains to enlarge and improve the remainder of that route all the way to the Gulf of Mexico and to open the mouth of the great Mississippi River, to permit the rapid escape of the flood waters, and to improve its navigation; but the means to this end cannot be treated in the limits of this paper. Suffice it to say that it is still a present problem, as is admitted by the last report of the Mississippi River Commission in these words: "Experiments are continually being made looking to the best use of the available material and the development of appliances and methods which may be economically and effectively employed when Congress shall provide for such systematic improvement."

This quotation serves to emphasize one of the most serious obstacles to the development of the commercial interests of the country, namely, the meagre appropriations made only biennially by Congress for works of this class. Attention is also directed to the absence of all competition in the preparation of the designs and plans and to the rigid requirements of the specifications, which have the effect of deterring many responsible companies from underwriting government contracts, thus increasing the cost of these important improvements with no guaranty as to the results to be secured.

The effect of the absence of cheap water transportation from the interior to the seaboard is impressively exhibited by the fall in the average farm-price of the staple cereals as the distance from the seaboard increases. The export price being the standard, the cost of the overland haul must be deducted to determine the farm-value. It is found from the statistics of the Department of Agriculture, during the past decade, that if the average price of wheat on the Atlantic seaboard is 79 cents per bushel, it will be 78 cents for New York State; 72 for Pennsylvania; 69 for Ohio; 65½ for Indiana; 64 for Illinois; 60.8 for Missouri; 58 for Iowa; 53 for Kansas; 50.9 for Nebraska, which is the lowest area reached.

The ability to ship via Kansas City and St. Louis down the Mississippi River contributes to raise the value of farm-products in Kansas as compared with Nebraska to such an extent that Nebraska would have saved nearly $15,000,000 in one year could her crops have been sold at Kansas prices (in 1901).[1]

The same general principles prevail in other states, to raise the value of agricultural products and consequently of real estate, as the waterways are more accessible and capacious; yet the demands for their enlargement, improvement, and emancipation from tolls are far in excess of the ability of the Government to provide for them either financially or administratively. The total estimate for works required at the present time exceeds the entire cost for construction and maintenance of rivers and harbors, since the foundation of the Republic.

Yet private parties and localities are prohibited by law from relieving their own exigencies, by their own methods, at their own expense and risk, without charge upon commerce, thus compelling them to submit to the non-competitive tariffs, which restrain trade and drive it to other more favored locations, or to go into liquidation.

There would seem to be great necessity for further remedial legislation in line with the recent resolutions of the National Board of Trade, authorizing the letting of contracts for this class of work

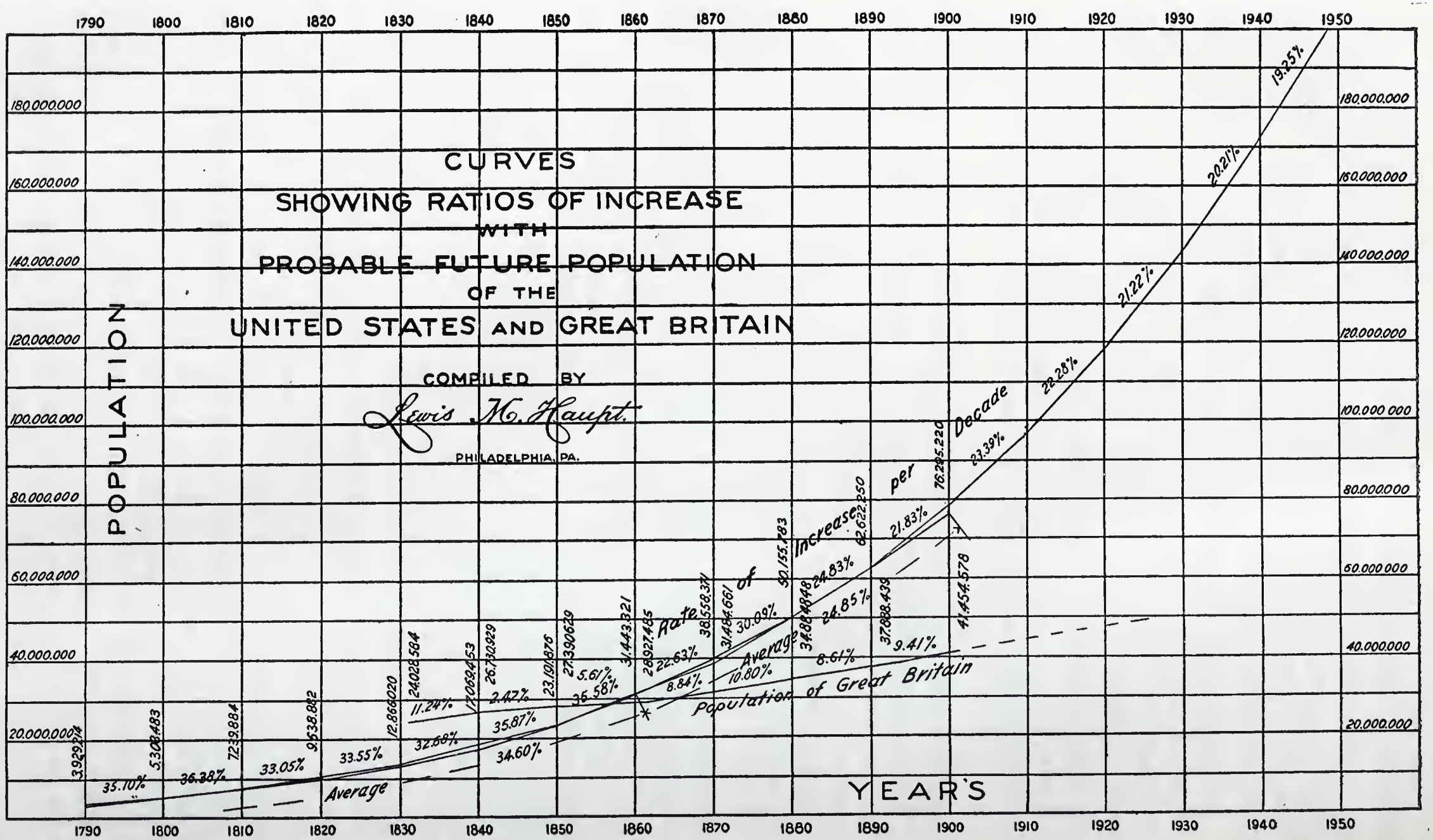
[1] See *The Forum*, January, 1903: *Waterways, An Economic Necessity.*

CURVES
SHOWING RATIOS OF INCREASE
WITH
PROBABLE FUTURE POPULATION
OF THE
UNITED STATES AND GREAT BRITAIN

COMPILED BY

Lewis M. Haupt.

PHILADELPHIA, PA.



upon the basis of payments for results secured, by whatever method.

These details of transportation, and their related factors of legislation, finance, and policy, have been elaborated to some extent, since they affect the well-being of the people of all nations. It is as true to-day as in the time of MacCauley, that the civilization of a country is determined by the conditions of its highways, and yet, as has been shown, the provision made for this purpose in this country, at least for common roads and waterways, is wholly inadequate to meet even present demands. We have no executive department of highways, and that for waterways is but an adjunct to the military arm of the government, presumably inaugurated for the movement of naval vessels in the event of war and not to promote the arts of peace and commerce, such as exist in other great nations of the world. The general demand for national aid for our public roads should meet with a prompt and generous response from the general government as well as from all sections of the country in a local coöperation, to place the highways of the nation, state, county, or township in the best possible condition, and for this purpose all legitimate local influences should be concentrated upon the citizens who are selected to represent their constituents in the honorable service of legislation, to secure their active efforts in its behalf.

The momentous importance of immediately providing for the more general and cheaper distribution of the products of the earth is apparently not fully realized, and certain it is that the increased supply of transportation has not kept pace with the demand. The operating expenses of some of the best managed trunk-line railroads, last year, were increased 25 per cent because of their overtaxed facilities.

It does not appear to be generally known that the population of the United States is increasing at a more rapid ratio than that of any other portion of the globe and that by the year 1935 the enumeration of the last census will have become doubled, while the tonnage movement is expanding at a much more rapid rate, in consequence of the greater output of mines, mills, and manufactories, as well as from the increased acreage under cultivation.

As this is a fundamental element affecting all industries, it is respectfully submitted to this distinguished Congress in a carefully compiled graphical diagram, showing the increments of growth during the past century, as actually recorded, subject to all the vicissitudes of wars, famines, plagues, immigration, births, deaths, and conditions of servitude which affect vital statistics, and to these data the curve of population has been closely applied and its law of evolution determined. It is thus found that the incre-

ment per decade has decreased by a constant which reduces any ratio one twenty-first less than that of its predecessor.

By projecting this curve forward, subject to this law of decreasing percentages, a very close approximation may be obtained for the future, which will serve as a reliable basis for the solution of the many social, industrial, commercial, and financial problems, based on population.

Thus there results for the present half-century, the following tabular statement:

PROBABLE INCREASE IN POPULATION OF THE UNITED STATES DURING THE PRESENT SEMI-CENTENNIAL

Date.	*Rate of Increase.*	*Population.*	*Numerical Increment*
1900		76,295,220	
1910	23.39	94,249,201	17,952,298
1920	22.28	115,266,772	21,017,571
1930	21.22	139,703,327	24,436,555
1940	20.21	167,923,399	28,220,072
1950	19.25	200,248,653	32,325,254

Hence it appears that within the lifetime of many of our contemporaries the population of this great republic may reasonably be expected to increase 2.6 times, or 260 %, which is at the average rate of 52 % each decade, thus showing the effect of compounding of the curve due to the decennial increment.

Urban Population

But it is not merely the rapid growth in numbers for which adequate provision should be made. The distribution of the population is quite as important a problem. With the centralization in great communities the engorgement has become not only inconvenient, but at times oppressive and even dangerous. Ferries, trolleys, elevateds and subways, bridges, and tunnels are all taxed to their utmost limits, and the headway of trains is reduced to the danger-point, yet the facilities are wholly inadequate for the morning and evening service between dormitory and shop.

Moreover the daily tonnage of food required to be furnished to man and beast, and the waste required to be removed from the great manufacturing centres, is enormous, thus greatly increasing the risks to life and health. This excessive concentration also leads up to the overcrowded tenements, sweat-shops, and brothels, with their unwholesome environments and immoral diversions; for all of which the most tangible remedy is dispersion.

The density of the population should be held within safe limits by strict sanitary legislation, centres of industries should be estab-

lished in rural districts, thus requiring shorter hauls for dairy and agricultural supplies and creating local markets for many products. The utilization of waterfalls for the generation and transmission of power to long distances will aid in this effort to distribute the laboring classes to their manifest advantage.

So great is the traffic on the municipal lines that the patronage in many cities exceeds 300 times the total population, per annum, which at times greatly surpasses the capacity of all the cars in the service. There is apparently no relief in sight, excepting the addition of a double deck to the elevated railroads or the introduction of a series of continuously moving sidewalks having different relative velocities, which latter method has been frequently proposed but appears to have many disadvantages, especially in the requirements for space, cost, and freedom from danger and noise.

So long, therefore, as movement is confined to the surface, elevated. or underground roads, the difficulties of handling the traffic must increase in a very rapid ratio unless the population can be confined to smaller local centres or be removed from the surface altogether. This desideratum has given rise to many efforts to construct some practical device for *aërial navigation*, and thus it happens that there is still a medium into which man's ambition would lead him, like Icarus, to soar, were it possible to find some antidote for gravity.

Much progress has, however, been made in the construction of dirigible balloons and special forms of captive kites, which give promise of becoming of commercial value as means of communication and for collecting data, in this rarer medium. It is therefore a part of the laudable purpose of the management of this Exposition to encourage this effort by the awarding of large premiums for the most successful practical efforts. The problem is most alluring because of the manifest advantages to result from its fruition. Instead of having to improve waterways, or to build railways and highways at enormous cost for construction and maintenance, the way would be free to all. There would be no bridges, tunnels, toll-gates, sand-bars, reefs, or other obstacles to the ready interchange of commerce. No custom-houses, forts, or frontiers. Commercial and military barriers would be obliterated and wars would soon become a memory. Were the inhabitants of the earth able to "move like an army of locusts with banners," seeking the garden-spots of the globe, what would become of the Chinese Exclusion Act or the laws restricting pauper immigration? Then would it appear that "the earth is the Lord's and the fulness thereof, the world and they that dwell therein;" for man could seek his own environments much better, and more readily secure the opportunity to earn his bread

by the sweat of his face, denied to so many under existing social conditions.

With the inspiring precedent set by Mother Earth herself, floating through an imponderable ether, and held in her courses by the mutual attraction of celestial bodies, and with the wonderful mechanisms of the myriads of beasts and birds constantly mocking the climax of God's creatures, it is not surprising that man should set himself sedulously to the task of surmounting the circumambient clouds and seek to convey himself through a ponderable atmosphere, by flight.

In the mean time the world awaits his efforts with hope and expectation that unknown resources and energies may soon add wings to time and solve the long-desired paradox of aërial navigation.

In conclusion, from this general review of the technological field in civil engineering it will be seen that while much has been revealed and applied in the utilization of the forces and resources of this wonderful planet, there is still much to be discovered. The pregnant past has showered upon this generation coal, oil, and gas; steam, compressed air, and water-power; dynamite and melonite; the turnpike and railway; the palace-car and ocean greyhound; the bicycle and automobile; the telegraph and telephone; and the wizard electricians are now prophesying, like Puck, that they will put a girdle round the earth in forty minutes and will furnish millions of electrical horse-power from a central plant, to any part of the world without metallic conduits.

Quid nunc? Is this only a dream? Who knows? Yet the wheels of progress are ever revolving in an ascending gradient, surmounting obstacles, spanning chasms, uniting continents, eliminating distance, abridging time, and lifting humanity upon the higher planes of consecrated labor to the lofty summits of a Christian civilization.

But to be more specific as to the work before us, it may be said that there is still great need of further improvement in the utilization and transmission of power of all kinds, both by movable and stationary engines; in the application of natural forces to remove and prevent the formation of alluvial bars in commercial channels; in the improvement and extension of better highways for the transportation of materials; in the betterment and standardization of the rolling-stock used in the conveyance of freight and passengers; in the more general introduction of pneumatic plants for the distribution of the mails and for local deliveries in great cities, to reduce the congestion from the delivery-wagons; in the construction of subways for the installation of public-service conduits, sewers, water-supply, lighting, power, drainage, and interurban

traffic; in the original provision, in the planning of cities, for all classes of municipal service, prior to the establishment of new strategic, commercial, and populous centres; in the timely equipment of existing towns, in anticipation of the rapid expansion of the population, due to the compounding increment of growth; in additional terminal facilities at points of trans-shipment, to avoid delays and demurrage in port; in the utilization of tidal energy; in continued efforts to attain practical results in aëronautics; and in many other special branches of technology too numerous to mention.

That these desiderata may be attained, it is fundamental that the religious, social, financial, and legislative conditions be made to harmonize by broad and wise laws and statecraft, giving ample opportunities for the utilization of the best-known methods and resources which the country affords, for it is found that law is sometimes a serious obstacle to progress in not keeping pace with nor anticipating the demands of science.

It is not wise to limit our scope to present problems nor confine attention to the fleeting moments. There is a duty which this generation owes to posterity, and it must be met, that history may accord to us the credit of having "builded better than we knew," by laying broad foundations that its pathway be not incumbered by our errors of judgment nor by a narrow cupidity which makes provision only for the passing hour.

Then will the people of our day and generation be true to their heritage, realize their responsibilities, and transmit to the future a basis for still greater aspirations and attainments in the arts of peace and the science of government, that wars may cease and good will prevail amongst the sons of men, for "righteousness exalteth a nation" and "wisdom is justified of her children."